Arctic stratospheric ozone loss as observed over Kiruna, Sweden, during winter/spring 2004/05

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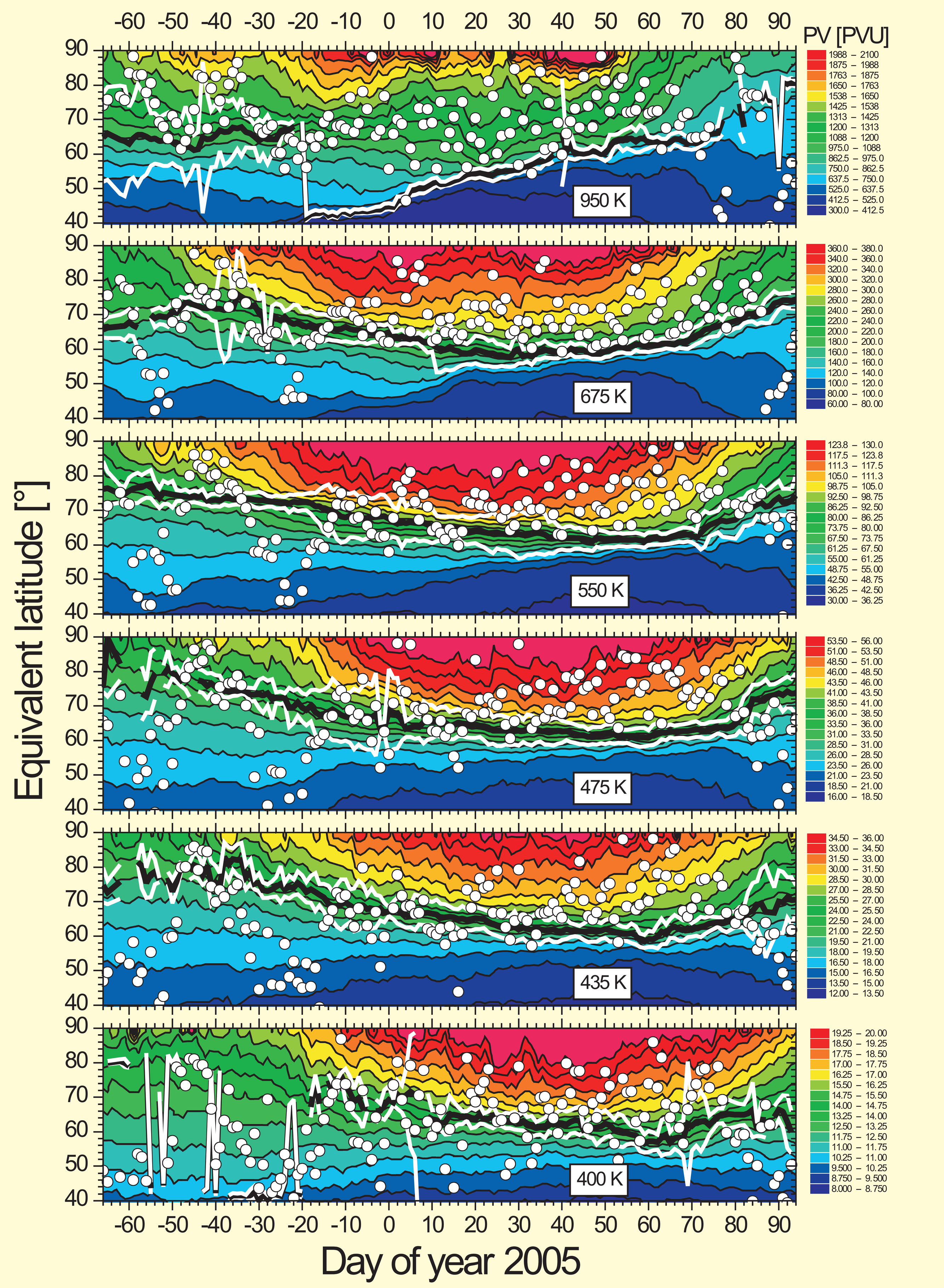

Figure 1: Evolution of the polar vortex in terms of equivalent latitudes. The white lines describe the inner and outer edge of the vortex, respectively, while the black line describes the mean vortex edge, i.e. the strongest gradient in PV for the particular day. The colour coding shows the strength of the vortex in PVU. The open circles depict the PV over Kiruna on the particular measurement days and refer to the underlying PV colour coding, showing how far away from or how deep inside the vortex a measurement has been taken at IRF.

Introduction

IRF Kiruna is located above the polar circle (67.8 N/20.4 E) investigating the peculiar processes in the atmosphere such as the aurora and the ozone layer within the polar vortex during Arctic winter. The ground-based observations of stratospheric trace-gases by the IRF millimetre wave radiometer KIMRA cover the altitude range from 15 up to 55 km. Here we present observations of stratospheric ozone covering the entire winter/spring period 2004/2005. KIMRA was operated almost continuously and from the measurements we calculated ozone profiles and column densities. For the estimated ozone loss we considered only measurements well within the polar vortex defined by the 'Equivalent Latitude' method described by Nash et al. [1996]*. In order to discriminate dynamic effects we deploy N_2O data from the Odin satellite.

* Nash, E. R., P. A. Newmann, J. E. Rosenfield, and M. R. Schoeberl, An objective determination of the polar vortex using Ertel's potential vorticity, J. Geophys. Res., 101, 9471 - 9478, 1996.

Measurements

KIMRA is a heterodyne radiometer with a cryogenically cooled Schottky mixer. It measures thermal emission lines of stratospheric trace gases like ozone in the frequency range 195-224 GHz. Continuous ozone observations with KIMRA have started in January 2002 providing a time series of almost uninterrupted ozone data. The data in figure 2 present the period November 2004 to March 2005.

For the retrieval a modified 'Optimal Estimation Method' (Rodgers, 1976)** is used. Deploying the FWHM of the averaging kernels we can obtain a vertical resolution of the ozone profiles of at best 7 km (at 25 km altitude). Contributions from the measurements to the retrieved profile are typically higher than 75% in the altitude range from 15 to 55 km. However the partial column densities are calculated for 10 to 60 km.

** Rodgers, C.D., Retrieval of Atmospheric Temperature and Com-position from Remote Measurements of Thermal Radiation, Reviews of Geophysics and Space Physics, 14, 609--624, 1976.

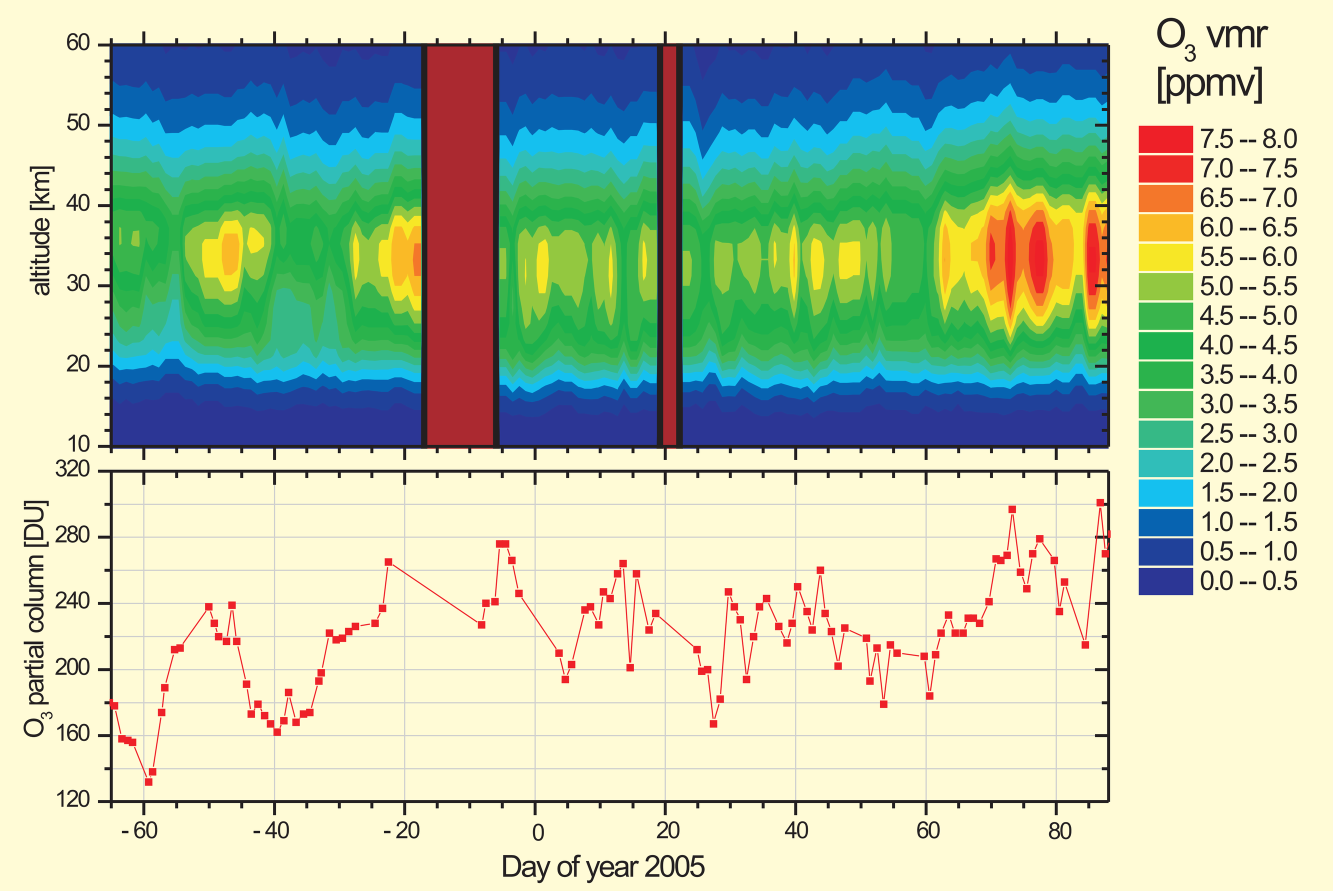

Figure 2: Time series of ozone during winter/spring 2004/05 (upper panel). The contour plot shows the volume mixing ratio in ppmv. The lower panel presents the partial ozone column density from 10 to 60 km.

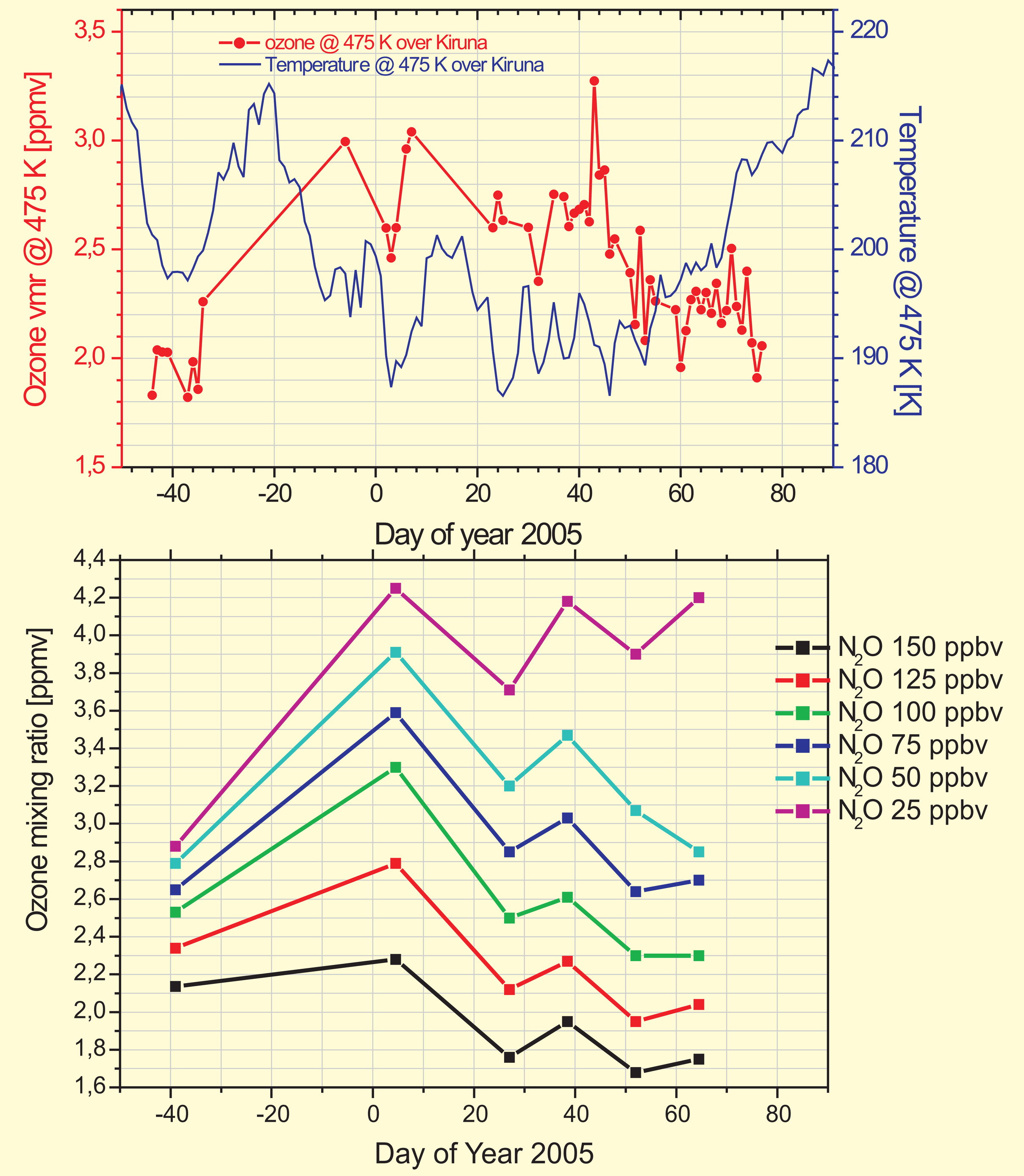

Figure 3: The ECMWF temperature over Kiruna and ozone volume mixing ratio on the 475 K isentropic surface (upper panel). Data points depict inside vortex measurements only. In the lower panel the same vmr data are calculated for N_2O isopleths provided by Odin data in order to eliminate effects of diabatic subsidence.

Results

The Arctic winter 2004/05 has started with very low temperatures in December and January. The minimum temperatures for this winter period were reached in January when also polar stratospheric clouds have been observed. The upper panel of figure 3 shows the ECMWF temperatures on the 475 K isentropic level along with the measured ozone vmr values on the same level. Part of the total ozone loss is covered by the diabatic subsidence inside the vortex. In order to correct for the diabatic subsidence Odin vortex mean values of N_2O are used. All measurements shown in the lower panel of figure 3 are taken inside the vortex and show a clear decrease in the volume mixing ratio of about 21% during January. The much higher vortex averaged temperature in February and March stopped the initially strong ozone depletion. The somewhat unusual vmr increase at the beginning of the winter has also been observed in former winters. The estimated vortex averaged ozone loss amounts to about 25 - 30%.

Acknowledgements

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